The MAX-MEX T1-T2 Component of the MILAGRO Campaign

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Introduction

The T1-T2 study was designed to investigate changes in the mass absorption efficiency α_{ABS} (absorption per unit mass, with units of m^2/g) of elemental carbon (EC) downwind of Mexico City at two sites, T1 and T2. The T1 site was located at Tecamac University and the T2 site was situated approximately 35 km to the northeast at Rancho la Bisnaga. We hypothesized that the shift from an externally mixed state characteristic of fresh emissions to an internally mixed one would result in significant modifications to the optical properties of aerosols containing EC as those aerosols were advected downstream from Mexico City. Figure 1 shows a map of the Mexico City area and the locations of sites T1, T2, and a third site, T0, at the Instituto Mexicano del Petróleo.

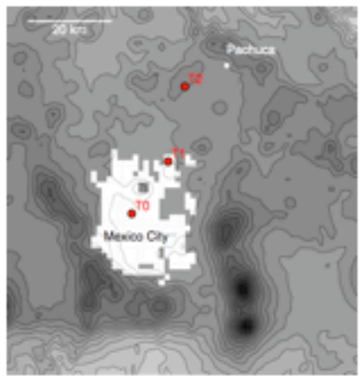

Figure 1. Map of the Mexico City area showing locations of T0, T1, and T2. The contour intervals are 200 m.

Previous field estimates of α_{Abs} for black carbon have ranged from 2 m^2/g to 25 m^2/g. Recently, Bond and Bergstrom (2006) suggested that freshly emitted, uncoated soot particles have a value of $\alpha_{ABS} = 7.5 \pm 1.2$ $m^2\ g^{-1}$ at 550 nm. This "uncoated" value will increase as the particles age and become coated, which may explain some of the range in measured values of α_{ABS}, but the rates at which aging occurs and direct observations of changes in α_{ABS} downstream from a source have been difficult to determine in the field.

Instruments

For the T1-T2 study we sought to obtain data from pairs of instruments, with one of each pair located at both T1 and T2. The instruments included radar wind profilers (RWPs), radiosondes, organic and elemental carbon (OCEC) analyzers, photoacoustic absorption spectrometers (PASs) operating at 870 nm, 3-wavelength, nephelometers (450, 550, and 700 nm), particle soot absorption photometers (PSAPs; 470, 530, 660 nm), and multi-filter rotating shadowband radiometers (MFRSRs; 415, 500, 615, 673, 870, and 940 nm). In addition to these ground-based instruments, several aircraft made flights over T1 and T2 during the campaign. Some initial measurements are reported here.

Results

Figure 2 show times series of specific absorption at the two sites. These values were found by combining the EC measurements from the OCEC analyzers with the absorption data from the PASs. Operation of the PASs at 870 nm is advantageous because although EC does absorb at this wavelength, the absorption of other atmospheric constituents such as dust and OC is quite weak. In general the specific absorption values for EC at T2 were higher than those found at T1.

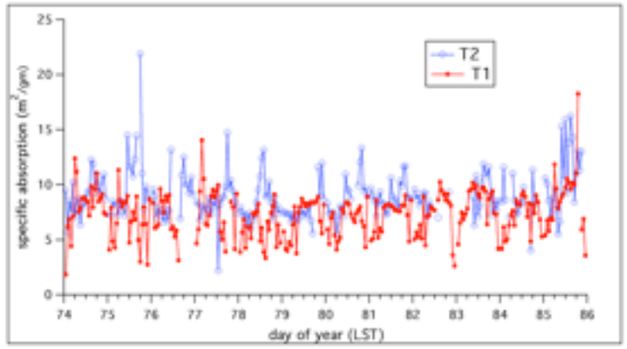

Figure 2 Time series of specific absorption of EC at 870 nm at the T1 and T2 sites.

Figure 3 shows histograms of the distributions of hourly values of specific absorption at the two sites. The median value at T1 is 7.5 $m^2\ g^{-1}$ and the distribution is skewed toward smaller values. In contrast, at T2 the median value is 8.5 $m^2\ g^{-1}$ and the distribution is skewed toward larger values. This behavior is consistent with the presence of more aged aerosols at the T2 site , which is more distant from Mexico City and significant sources of recently emitted EC than T1. Occurrences of specific absorption values less than 7 $m^2\ g^{-1}$ are relatively uncommon at T2 but are found over 40% of the time at T1.

Plume Trajectories

We were interested in possible differences in aerosol properties during periods when the winds blew the urban plume over both T1 and T2 and periods when they did not. For this initial analysis we have used the wind data obtained from the RWP at T1 to calculate forward and back trajectories of air masses that passed over T1. We classified periods when air parcels originating over the city and passing near T1 subsequently passed within 5 km of T2 as "transport" periods. All other periods were lumped into the "non-transport" category. We anticipated that during transport periods more recently emitted aerosols with lower values of α_{Abs} would be found at both T1 and T2. Conversely, during other times the aerosols at the two sites would be more likely to have aged for periods of hours to days. Figure 4 shows examples of trajectories calculated at 1000 m above ground level (AGL) for daylight hours over a 20-day period. The most favorable conditions for T1-T2 transport occurred on day of year (DOY) 69, 77, 78, 79, and 83, (March 10, 18, 19, 20, and 24, respectively) with briefer periods of suitable wind directions occurring on several other days.

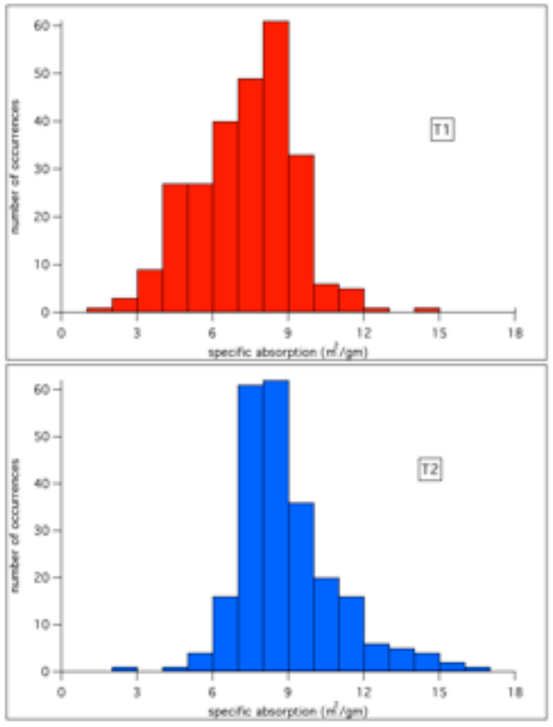

Figure 3. Histograms of hourly values of specific absorption of EC at T1 and T2.

Table 1 breaks the specific absorption results down to show the differences between transport and non-transport periods. Values of specific absorption are indeed smaller at both sites during transport periods when fresh emissions are more likely to be found. For both transport and non-transport periods, values of specific absorption at T2 are larger than those at T1.

The single scattering albedo of aerosols was measured with instruments on the G-1 aircraft, from the PSAP and nephelometer at T2, and from the MFRSRs, and initial comparisons show generally good agreement. To date we have not found significant differences in the single scattering albedo values measured during transport and non-transport periods, although additional analyses are planned.

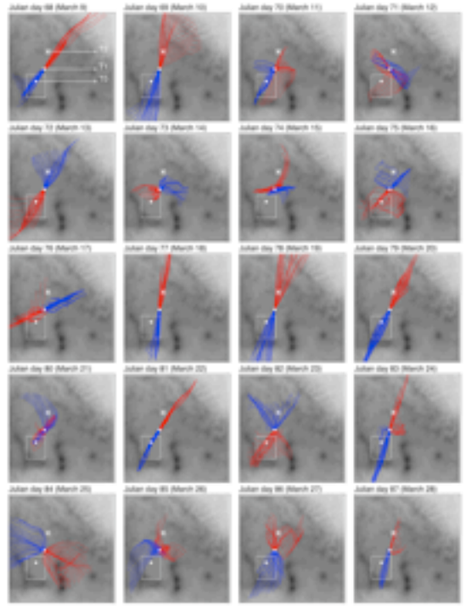

Figure 4. Trajectories of air parcels at 1000 m AGL during daylight hours derived from RWP data at T1.

	T1			T2			
	median	10th percentile	90th percentile	median	10th percentile	90th percentile	number of hours
transport periods 870 nm	7.2	4.1	9.2	8.0	6.7	10.8	59
non-transport periods 870 nm	7.8	4.8	9.7	8.6	7.1	11.9	166

Table 1. Median, 10th, and 90th percentile values of specific absorption at T1 and T2 during transport and non-transport periods. Values are in $m^2\ g^{-1}$.

Reference

Bond, T.C., Bergstrom, R.W., 2006. Light absorption by carbonaceous particles: an investigative review. Aerosol Sci. Technol., 40, pp., 27-67. doi:10.1080/02786820500421521.